POWER LOSS FOR MULTIMODE WAVEGUIDE AND ITS APPLICATION TO BEAM-WAVEGUIDE SYSTEMS”

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INTROIIUCTION:

The conventional way of expressing power loss in dB/meter for a multimode waveguide system with finite wall conductivity (such as a beam-wavcguidc system with protective shroud) can be incorrect and misleading. The power loss (in dB) for a multimode waveguide system is, in general, not linearly proportional to the length of the waveguide. New power loss formulas for multimode system arc derived in this paper for arbitrarily shaped conducting waveguide tubes. In these formulas, there arc factors such as $(\exp(jx)-1)/(jx)$, where $x = (\beta_a - \beta_b)l$, with β_a and β_b being the propagation constants of the different propagating modes and 1 being the distance from the source plane to the plane of interest along tbc guide. For a large beam-wavcguidc supporting many propagating modes, β_a's are quite close to fib’s, thus the mode coupling terms remain important for a very long distance from the source plane.

The multimode power loss formula for a large circular conducing tube has been verified by experiments. ‘l’his formula was also used to calculate the additional noise temperature contribution due to the presence of a protective shroud surrounding a millimeter-wave beam-waveguldc system.

APPLICATION TO BEAM-WAVEGUIDE NOISE TEMPERATURE COMPUTATIONS:

Large beam-wavcguidc-type ground station antennas arc generally designed with metallic tubes enclosing the beam-wavcguidc mirrors. The scattered field from a beam-wavcguidc mirror is obtained by the usc of a physical optics integration procedure with a Green’s function appropriate to the circular

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waveguide geometry. In this manner, the coefficients of the circular waveguide modes that are propagating in the oversized waveguide arc determined.

Knowing the coefficients, onc may calculate the tangential magnetic fields for the TE and TM modes. The total tangential magnetic field is the sum of these tangential magnetic fields. Substituting the total tangential magnetic field into the power loss equations derived in this paper and carrying out the integral numerically, onc may readily obtain the total power loss P_L.

The above numerical approach was used to calculate the conductivity loss of a short length of beam-waveguide tube. The experiment utilized a 3.92-meter length of 2.5-meter-diameter **structure steel** tube and a very sensitive noise temperature measuring radiometer, Noise temperature comparisons were made between several different horns radiating in free space and radiating into the beam-waveguicfc tube. Utilizing the measured conductivity of the steel and the computed modes in the beam-wavcguide tube, a conductivity loss was computed and converted in(o a noise temperature prediction. For the 14.7 dB gain horn, the TE_{1p} and TM_{1p} modes to p=50 were included and for the 22.5 dB gain horn modes to p=22 were included. A comparison of the measurement with both the ncw theory derived in this paper and the conventional dB/meter formulation is shown in Table 1. The most dramatic difference was with the higher gain (22.5-dB) horn. It was this experimental result which showed that the result obtained according to the conventional dB/meter formulation was incorrect. Tbc measurement was 0.1 K ± 0.1 K and there was no question that the calculation of 2.6 K from the conventional method was significantly outside the range measurement uncertainty, The explanation can be seen in a plot of the attenuation loss as a function of tube size. Because the high-gain horn docsn't "illuminate" the wall until further down the tube from its aperture plane, there is only a very small loss near the aperture. This clearly demonstrates the fact that the power loss is not linearly dependent on z and thus validates the analysis.

Table 1. Experimental Results

	Measured Kelvin	Calculated New Method, K	Calculated Conventional dB/meter, K
22.5 dBi gain horn with steel tube	0.1 ± 0.1	0.1	2.6
14.7 dBi gain horn with steel tube	2.5 ± 0.4	2.3	3.0